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SUBMITTAL OF PRIORITY DOCUMENT

Sir:

To complete the requirements of 35 USC 119, enclosed is a certified copy of the following Great Britain priority application:

0224862.3 filed October 25, 2002.

Respectfully submitted,

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Traci A. Brown

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Request for grant of a patent

25 OCT 2002

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1.	Your reference	10/02/030S
2.	Patent application number	0224862.3
3.	Full name, address and postcode of the applicant	AESSEAL plc Mill Close Bradmarsh Business Park Rotherham S60 1BZ
	Patents ADP number	8298648001
	State of incorporation	UK
4.	Title of the invention	AN INTELLIGENT SEALING SYSTEM
5.	Name of agent	Harrison Goddard Foote
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Intelligent Sealing System

This invention relates to mechanical seals, which are fitted to rotating equipment in virtually all types of industries.

A Mechanical seal comprises a "floating" component which is mounted axially movably around the rotary shaft of, for example, a pump and a "static" component which is axially fixed, typically being secured to a housing. The floating component has a flat annular end face, i.e. its seal face, directed towards a complementary seal face of the static component. The floating component is urged towards the static component to close the seal faces together to form a sliding face seal, usually by means of one or more spring members. In use, one of the floating and static components rotates; this component is therefore referred to as the rotary component. The other of the floating and static components does not rotate and is referred to as the stationary component.

Those seals whose floating component is rotary are described as rotary seals. If the floating component is stationary, the seal is referred to as a stationary seal.

If the sliding seal between the Rotary and Stationary components are assembled and pre-set prior to despatch from the Mechanical seal manufacturing premises, the industry terminology for this is "cartridge seal". If the Rotary and Stationary components are despatched individually (unassembled) from the Mechanical seal manufacturing premises, the industry terminology for this is "component seal".

Mechanical seals are used in all types of industries to seal a variety of different process media and operating conditions. The general industry term which defines the area adjacent to the process media is "inboard". The industry term which defines the area adjacent to the atmospheric side is "outboard".

RFID technology is used in conjunction with a data storage unit, typically a RFID storage chip. Said data storage unit contains data, which may be of use to the user. Such data may include product expiry date and/or product serial number. It is considered self explanatory that the design of the invention may also be applied with RFDC (Radio Frequency Direct Communication) as well as any other similar type of technology.

The data storage unit is located in the product. RFID technology allows the user to scan the data storage unit, from a distance, to access the information relating to the product.

This technology is ideal for complex products, which contain multiple options or configurations. The multiple options could be products with different colours, shapes, sizes, materials or specifications. Or ideally assembled products, which essentially look the same in appearance (from the outside) but contain different materials inside.

For the purpose of this application, products with multiple configuration options are termed as "complex assemblies".

Some data storage units are limited to "read" information only. These may be employed with complex assemblies in bar coding systems. More sophisticated data storage units have "read" and "write" capabilities.

Intelligent Sealing system

Rotating equipment includes pumps, mixers, reactors, agitators, basically any item of equipment, which pumps or mixes a product media.

All items of rotating equipment need sealing to prevent the pumped

media.

The invention is described with the aid of the following drawings.

Figure 1, illustrates a typical rotating equipment assembly, such as a centrifugal pump, fitted with a single rotary cartridge mechanical seal of the invention.

Figure 2 corresponds to Figure 1 and shows an enlarged partial cross section of the single rotary mechanical seal of the invention.

Figure 3, corresponds to Figure 2 and shows an enlarged view of the stationary seal face strain measurement device, which by way of example only is an anti-rotation pin with strain / resistance gauge attached.

Figure 4, corresponds to Figure 3 and shows an enlarged view of an alternate stationary seal face strain measurement device, which by way of example only is a strain / resistance gauge attached on or near to the drive slot.

Figure 5, corresponds to Figure 3 and shows an enlarged view of an alternate stationary seal face strain measurement device, which by way of example only is a linear gauge attached on a split drive ring.

Figure 6, shows a partial cross section of a double stationary seal with, by way of example only, an alternate seal face sensor arrangement.

Figure 7 corresponds to Figure 2 and shows an enlarged view of the drive screw with strain gauge / resistance attached.

Figure 2 corresponds to Figure 1. From *Figure-2*, of the invention, the rotary and axially floating seal face (11) is spring biased towards a static stationary seal face (12). The rotary seal face (11) is allowed to slide on the static seal face (12). The interface between the rotary seal face (11) and stationary seal face (12) forms sealing area (13). This sealing area (13) is the primary seal that prevents the process media (14) from escaping from the process chamber (15).

In addition to the sliding seal face (13), the process media (14) is sealed by a sleeve elastomer (16) in contact with the shaft (17) and sleeve (18). This has been termed the first secondary sealing area.

The second secondary sealing area is formed between stationary seal face (12) and stationary gland plate (19) using elastomeric member (20).

The third secondary sealing area is formed between the rotary seal face (11) and the sleeve (18) using elastomeric member (21).

The fourth secondary sealing area is formed between the gland plate (19) and the process chamber (15) using gasket (3).

The four secondary sealing devices (16, 3, 20 and 21) and the primary sliding sealing interface (13) prevent the process media (14) from escaping from the process chamber (15).

The static seal face (12) is prevented from rotating by at least one anti-rotational pin (22) mounted in the stationary member, in this case a stationary pivot ring (5). The pivot ring (5) is held stationary to the gland plate (19), by one or more anti-rotation features (6). The pivot ring (5) concept is further described in our co-pending application US509,379. Clearly the invention is not restricted to a pivot ring design. The invention applies to any design containing an anti-

This system, of the invention, essentially means that at periodic intervals, the force applied to the anti-rotation pin (22) can be recorded, time logged and saved on a RFID chip (29). This force can be evaluated against a benchmark force. Upper and lower force idealised limits can be established for different applications. Measured force limits can be compared to idealised seal sliding surface (3) forces and a precise assessment of the seal face (13) conditions can be made by the user.

From Figure 2, the RFID chip (29) is preferably embedded in the mechanical seal assembly (1). Since this chip (29) can be remotely read, the user does not have to be near the mechanical seal (1) in order to monitor the information contained on the RFID chip (29). This will be further explained later with reference to Figure 8.

This intelligent system, of the invention, can therefore provide an indication of whether or not the seal (1) is performing well. This information can be used in a preventative maintenance program, to provide an early warning of future seal (1) failure. An experienced reader will relate to the benefits of such an intelligent sealing system.

Figure 4, corresponds to Figure 3 and shows an enlarged view of an alternate stationary seal face strain measurement device (200), which by way of example only is a strain / resistance gauge attached on or near to the drive slot (201) on drive plate (202).

From Figure 4, the strain device (200) is permanately attached to the plate (202), preferably by adhesive. However it is understood that any other suitable means could be used, including mechanical attachment, chemical attachment and/or physical such as welding or brazing.

chip (36). The axial displacement change from the linear transducer (33) is amplified by the amplifier (34) and a signal sent to the micro controller (35). The micro controller (35) poles the data by checking or comparing the signal information to a benchmark reading and then date and time stamps it.

The time-logged information is then saved on the RFID chip (36). Clearly a read and write RFID chip (36) is employed so data can be saved and retrieved from the chip (36). The two aforementioned examples clearly show how one or more mechanical seal faces can be precisely measured by one or more sensors to determine the actual operating conditions at said seal faces.

There are other parts of the mechanical seal, which would benefit from this intelligent system of the invention. Examples of such features are herewith described.

From Figure 2, the sleeve (18) is axially terminated adjacent to the clamp ring (41) which contains at least one drive screw (42) for securing the seal assembly (1) to the shaft (17). Said drive screw (42) provides rotational drive from shaft (17) to the rotary components in the seal assembly (1).

Occasionally the vibration from the rotating equipment can cause the drive screw (42) to become lose. This results in premature seal (1) failure which can be a very expensive problem.

This drive screw (42) loosening process typically occurs over a period of time while the shaft (17) of the rotating equipment is rotating. Since the shaft (17) is rotating the drive screws (42) can not be checked without stopping the shaft. This, in most circumstances, is not practical. Furthermore, if a plant has 30,000 pieces of rotating equipment, it is impossible to stop and check every mechanical seal

resistance for each strain gauge (45) positioned adjacent to each drive screw (42) is noted. This change in resistance can be correlated to the torque applied by the user, for any size of drive screw (42).

As previously described, the strain gauge (45) is connected to an amplifier (50) which in turn is connected to a micro controller (51) and RFID chip (52). Said micro controller (51) and RFID chip (52) are mounted in a leak tight capsule (53) and secured to the clamp ring (41). Clearly, said capsule (53) may be sunk into the clamp ring (41) recess or hole, thereby preventing it from being damaged or knocked off.

The resistance change from the strain gauge (45) is amplified by the amplifier (50) and a signal sent to the micro controller (51). The micro controller (51) poles the data by checking or comparing the signal information to a benchmark reading and then date and time stamps it.

The time-logged information is then saved on the RFID chip (52). Again a read and write RFID chip (52) is employed.

This system of the invention could be used to allow the user to set the torque of each drive screw (42) to a precise displayed reading by using a remote hand held device. This remote hand held device will be described later with reference to Figures 11 to 15.

Since the foil strain gauge is secured on the clamp ring adjacent to each drive screw (42), if the drive screws (42) start to come loose in operation, then a change in resistance will be observed by the strain gauge (45). This would be detected by the user allowing the equipment to be stopped before catastrophic mechanical seal failure (1). This is deemed to be considerably advantageous.

There are many methods of which the drive screws can be monitored.

When the drive screw (80) is secured to the shaft (85), the proximity sensor (81) notes the proximity between it and the sensors on the drive screw (80). If the drive screw (80) becomes loose, the proximity between sensors (84) and proximity sensor (81) will change. This signal is again passed to an amplifier (88), a micro-controller (86) and stored on a RFID chip (87).

The experienced reader will note that all types of sensor devices, not just strain / resistance gauges, proximity sensors or linear transducers, could be employed by the intelligent system of the invention.

Sensory data acquisition may be collected using a number of devices for different applications. By way of example only, the following list illustrates typical types of sensors:

- Temperature fluctuations using thermal sensors,
- Pressure fluctuation using pressure transducers,
- Force fluctuations using stress, strain and/or force transducers
- Humidity using moisture sensors
- Vibration using accelerometers
- Resistively using resistance gauges
- Movement using linear displacement transducers

The experienced reader will note that any sensory device can be applied to the invention.

Figure 10, illustrates a schematic of the intelligent sealing system of the invention.

From Figure 10, it will be noted that signals from any number of the aforementioned sensors (100), located in the mechanical seal (101),

Figure 11, illustrates, by way of example only, a series of components situated inside a casing (111).

The RFID receiver (112) is connected to a RFID ariel / external antennae (113). The RFID receiver (112) receives the sensor data from the application, which is stored in the RFID chip previously described. The RFID receiver (112) sends the data to a micro controller (114). The micro controller (114) sends the information to a VFD display (115) which, is connected to a suitable power supply, in this case a battery (116). The display (115) is also connected to an earth terminal (117).

The micro controller (114) is preferably connected to one or more user control switches (118). Said switches (118) are connected to user control buttons (119) as shown in Figure 12. From Figure 11 said switches (118) are also connected to an earth terminal (119).

From Figure 11, the micro controller (114) is connected to a power switch (120) which, if activated connects the circuit to the power supply (116) therefore providing user operating power to the micro controller (114).

Furthermore, the micro controller (114) is connected to an external EEP ROM (electrically erasable programmable read only memory) data storage device (121), which in turn is connected to the power supply (116) and earth terminal (122). This allows the user to save collected data, then at a later date said stored data from the storage device (121) can be transferred through the 9 pin D-Type RS232 serial connector (123) to a computer or subsequent data processing device. Clearly, an alternate connector device (123) such as a 21 pin or 6 pin design, may be used where appropriate.

Preferably, although not essentially, the micro controller (114) is also

The micro controller (130) is connected to a power switch (131) which, if activated connects the circuit to the power supply (132) therefore providing power to the micro controller (130). From Figure 12, the power switch (131) is connected to at least one transistor (133). The transistor (133) is connected to at least two power supplies, the first is a solar cell (134) and the second is a battery (135).

When the power switch (131) is activated, the transistor (133) preferably sources power supply from the solar cell (134). In applications where there is insufficient power generated by the solar cell (134), the transistor (133) sources power supply from the battery (135), until such a time when the minimum power level is achieved by the solar cell (134). The transistor (133) then switches the power source to the solar cell (134) thereby elongating the finite battery (135) life.

It is self explanatory to an experienced reader that a rechargeable battery (135) could be employed in such a design of the invention. This thereby allows the solar cell (134) to recharge the battery (135) when the battery (135) is not in use.

In a design, of the invention, which does not contain a solar cell (134), as shown in Figure 11, the rechargeable battery (135) could be charged by connecting the device to an AC/DC adapter or portable unit as found in most automobiles.

Figure 13 illustrates a large quantity of LED displays (136). Figure 14 shows that these can be positioned either side of the display (140) allowing the user to visually display the sensored detail with respect to the control limits (142) on the displayed screen.

Figure 14, corresponds to Figure 13 and illustrates an alternate

attendant information is collected via RFID or any suitable data transmission device (167). Said data is continuously monitored (168) and could be saved to the database (164) as historical data.

If the user has inputted or retrieved incorrect variable data, the user is directed back to the input area (163).

The software algorithm, of the invention, compares the authenticated input data against the data acquisition stream and/or history (169). The output (170) is then shown as a process health status. The software of the invention may then suggest possible remedial actions (171), or allow the user to print (172) and/or send the data to an alternate application (173).

The output results are preferably logged in a database (164) for future use.

If remedial action (171) is taken, or if data is entered into the database (164), the application returns the user to the item attendant information collected point (167). The user may reiterate collection and storage sequences until such a time when the user wishes to move onto the next piece of equipment to be measured.

At such time, the application sends the user to the variable entering point (163).

It will be apparent to an experienced reader, that the design of the invention has considerable advantages in that the technology allows the remote monitoring of a given mechanical seal application so that the user can receive prior warning of pending problems.

It will be further noted that the design of the invention can be adapted for intrinsically safe applications also. By way of example only, to

inventory identification, while the product is on shelf, or product tracking, should the product be used for a different application which it was not intended for.

The repair of the product may also be fully tracked. Occasionally, during product repair conventional product identification marks are removed. As the invention has product identification stored on a data storage chip, this could be moulded or enclosed / captured into any number of components within the mechanical seal assembly. This is advantageous for product repair since the original information, including the original manufacturer details, is a permanent element of the construction.

and a data storage device.

8 An intelligent system in accordance with any preceding claims, where said sensor device is a strain measurement device which is permanently fixed to a component of the sealing system assembly, said strain measurement device is connected to an amplifier and/or a micro controller and a data storage device.

9 An intelligent system in accordance with any preceding claims, where said sensor device is a linear measurement device which is permanently fixed or non-permanently attached to a component of the sealing system assembly, said linear measurement device is connected to an amplifier and/or a micro controller and a data storage device.

10 An intelligent system in accordance with any preceding claims, where said data storage device is accessed by a remote unit consisting of a display, and/or keypad and remote antennae or receiver.

11 An intelligent system in accordance with any preceding claims, where said data is process by a software application with the sophistication to advise remedial process actions.

12 A sealing arrangement in accordance with any preceding claims, which contains an axially split drive collar, one end of said split drive is preferably fixed to the stationary part of the arrangement and the other end of the split is non-permanently attached to a sensor device.

13 An intelligent sealing system in according to claim 1 and claim 2 and substantially as herein described.

Figure 1 of 16

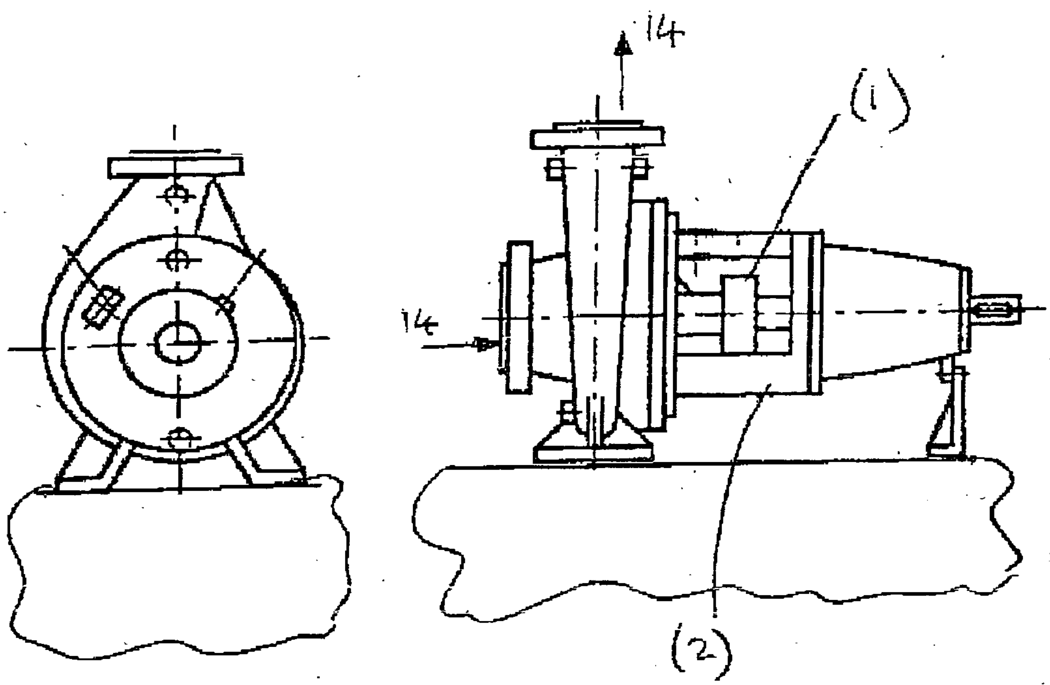


Figure 2 of 16

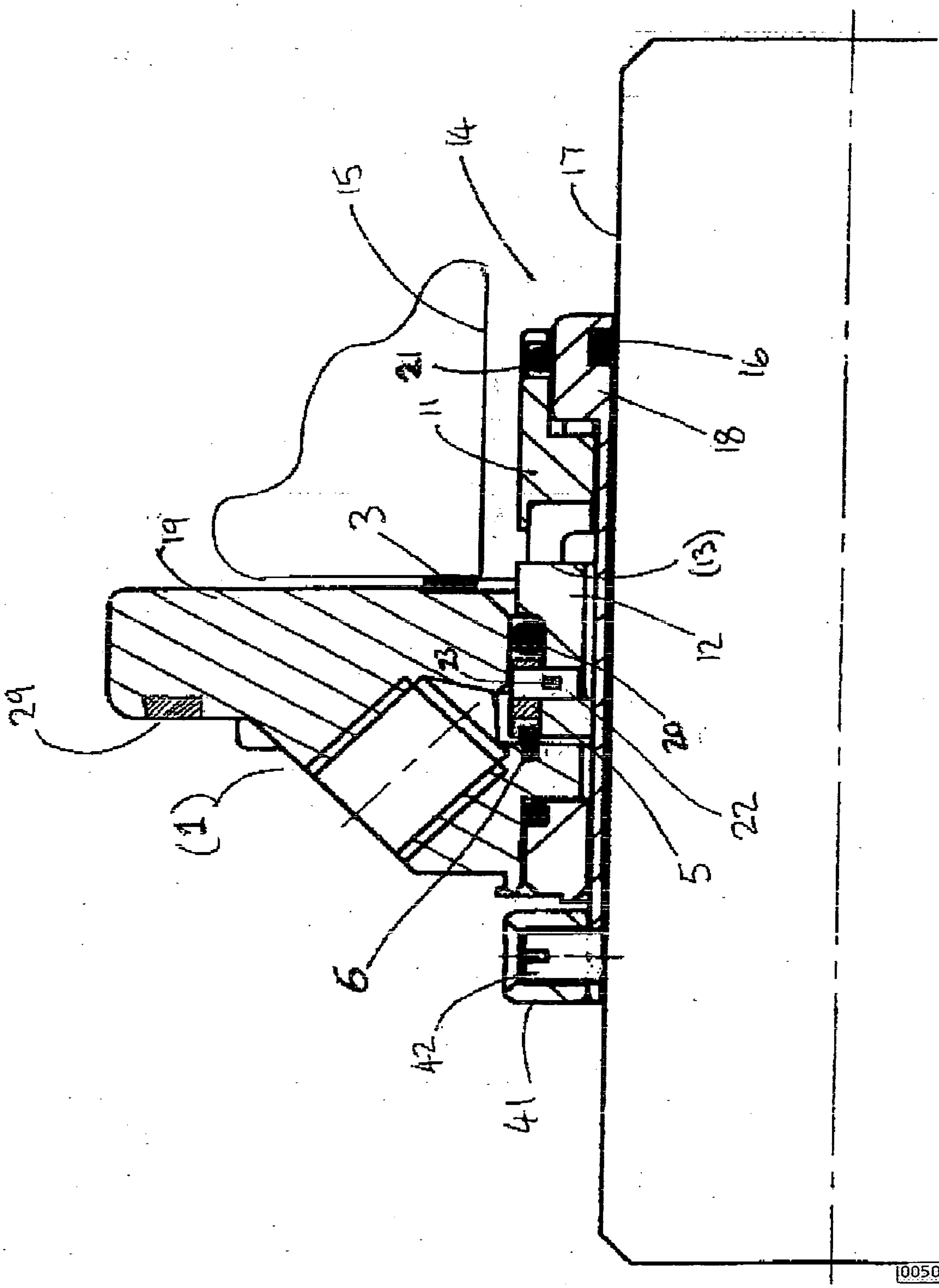
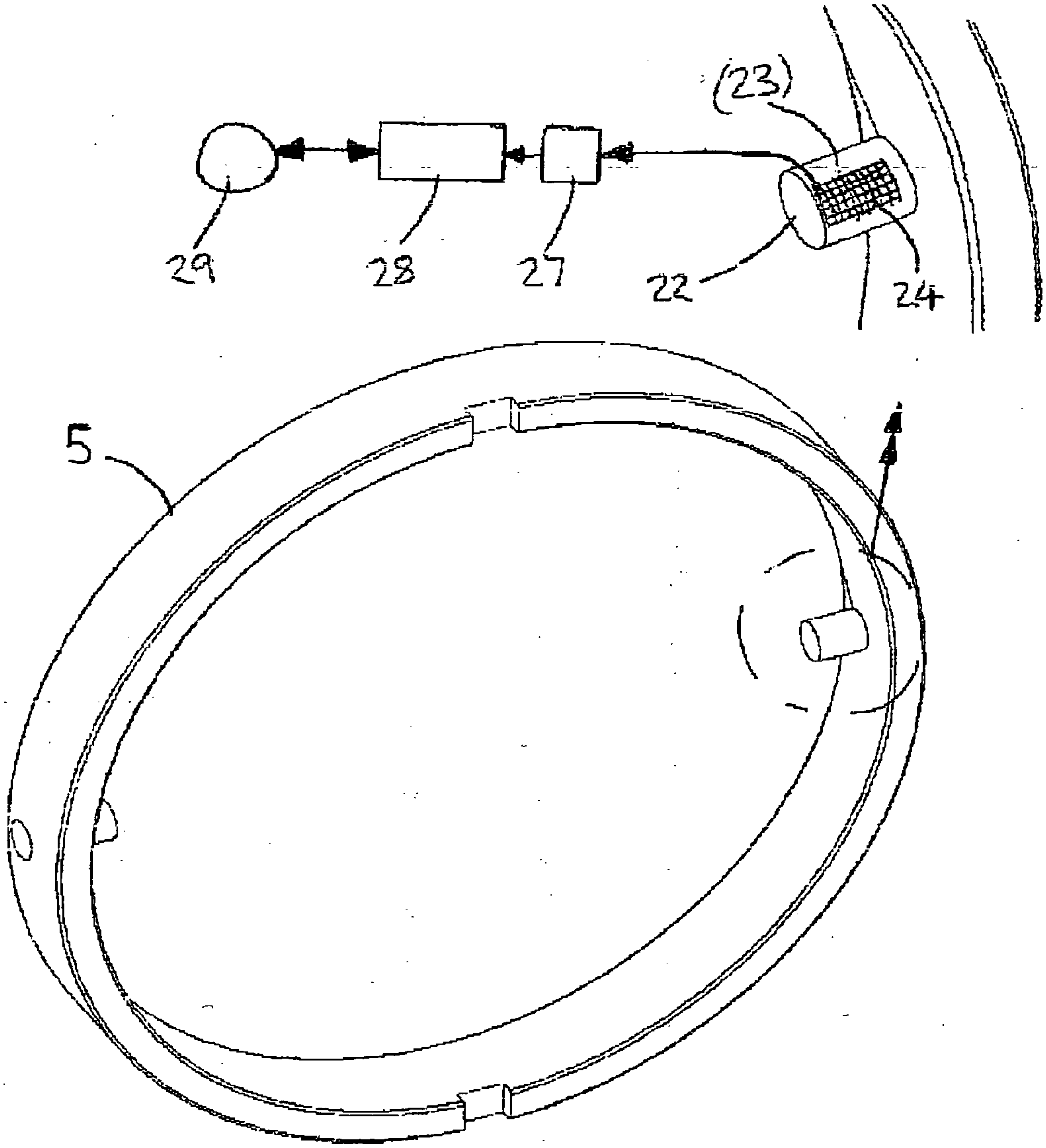


Figure 3 of 16



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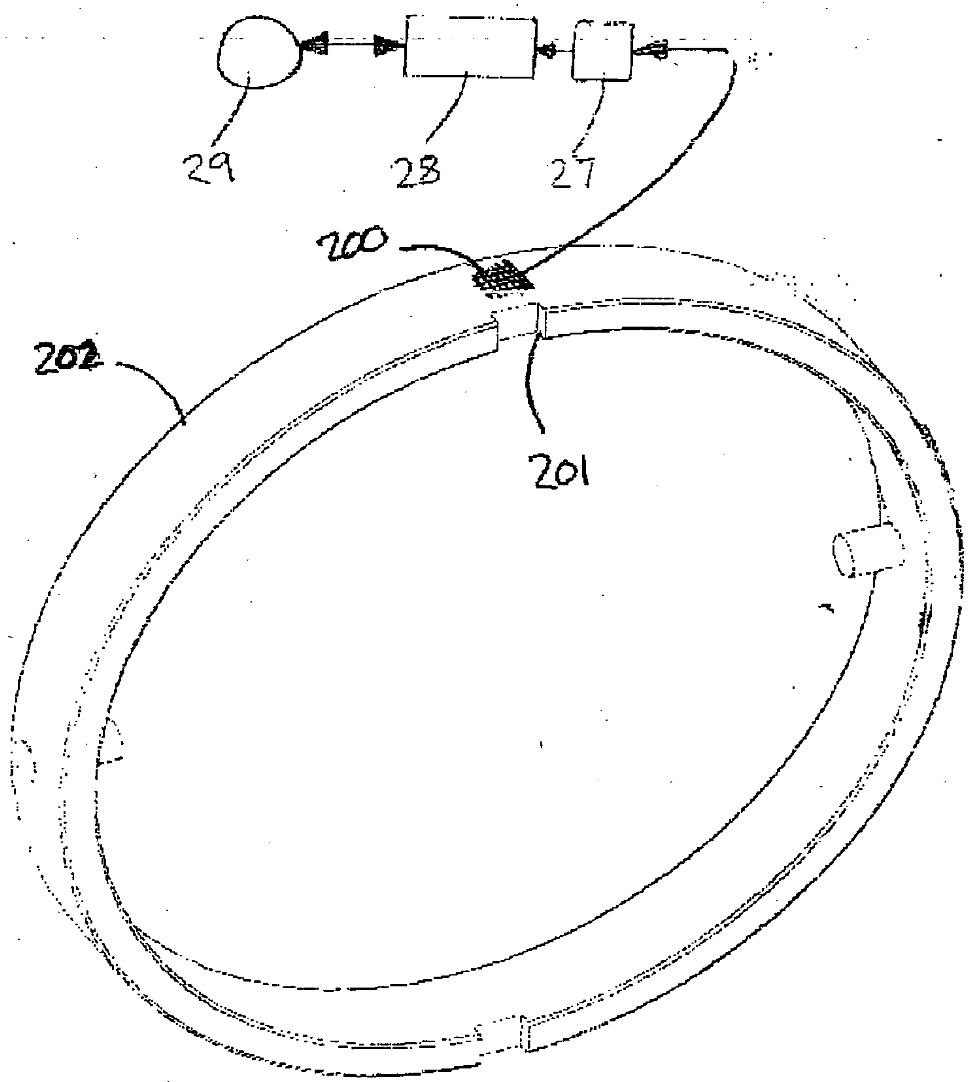

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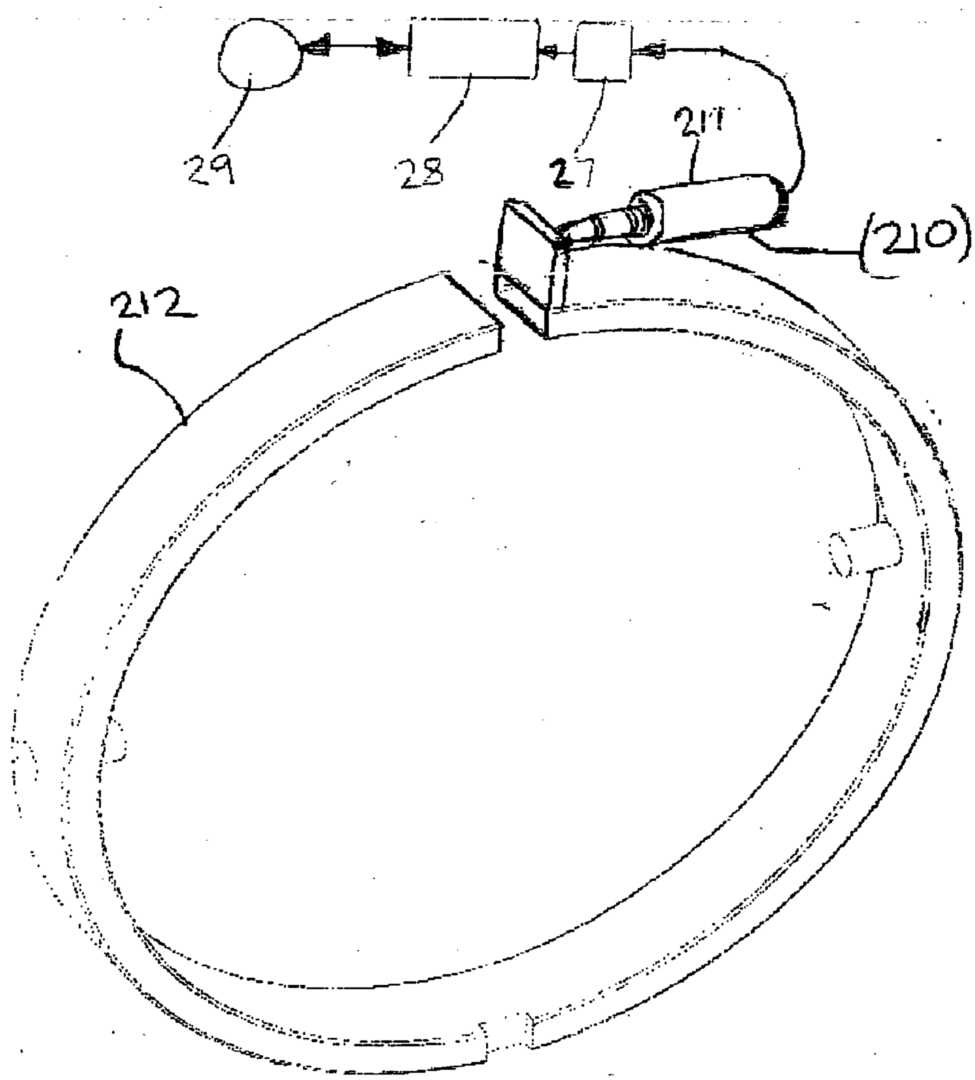


FIGURE 6 of 16

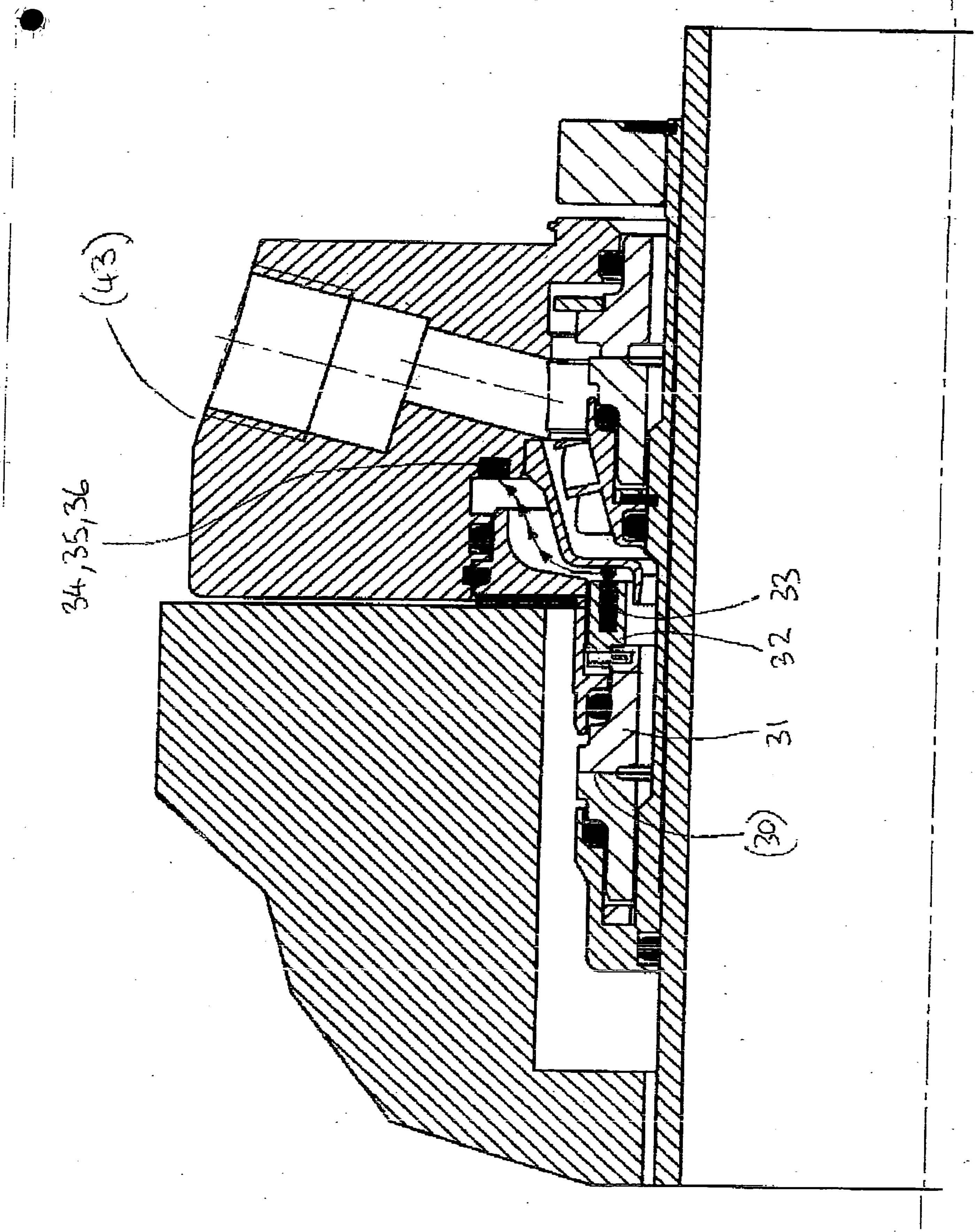


Figure 7 of 16

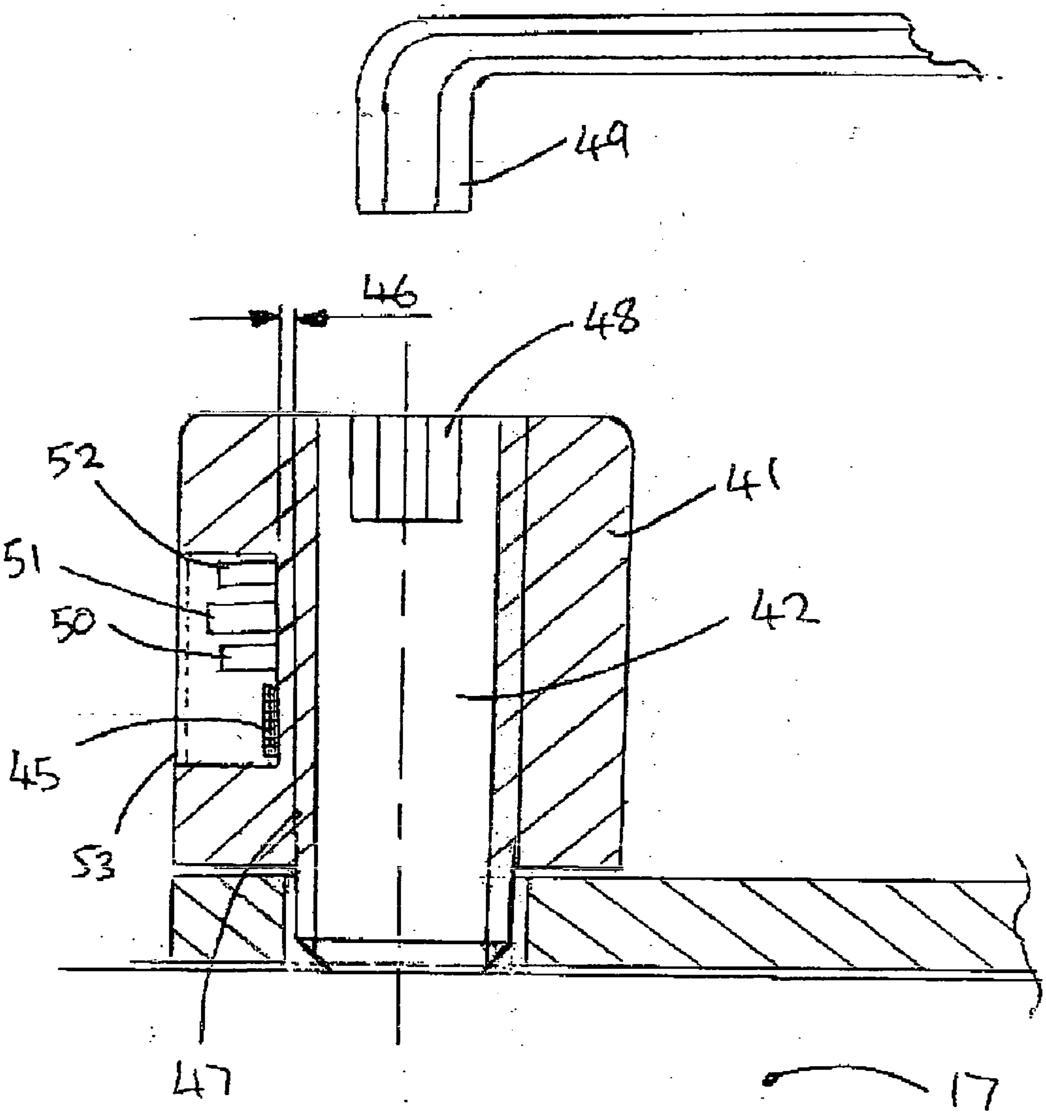


Figure 8 of 16

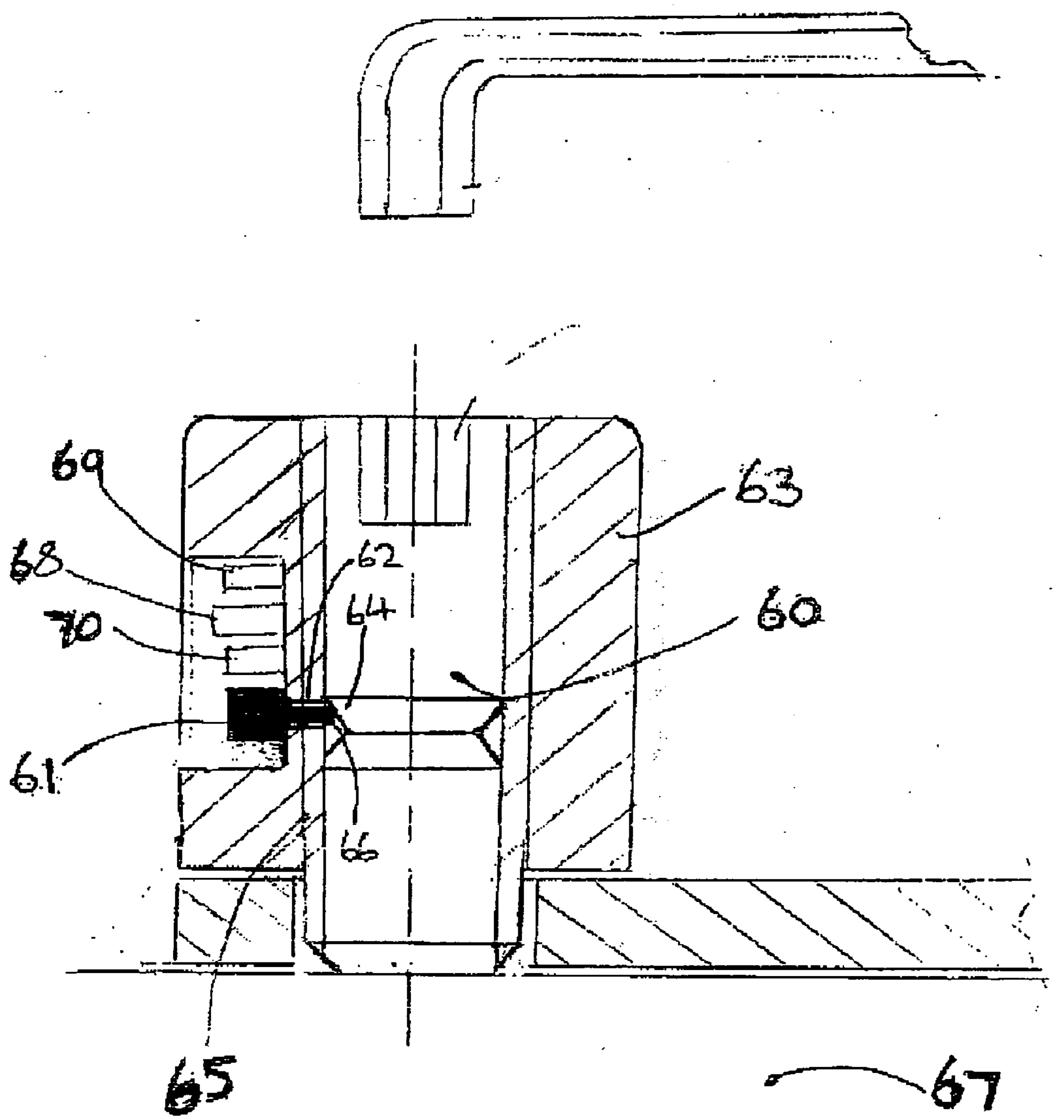


Figure 9 of 16

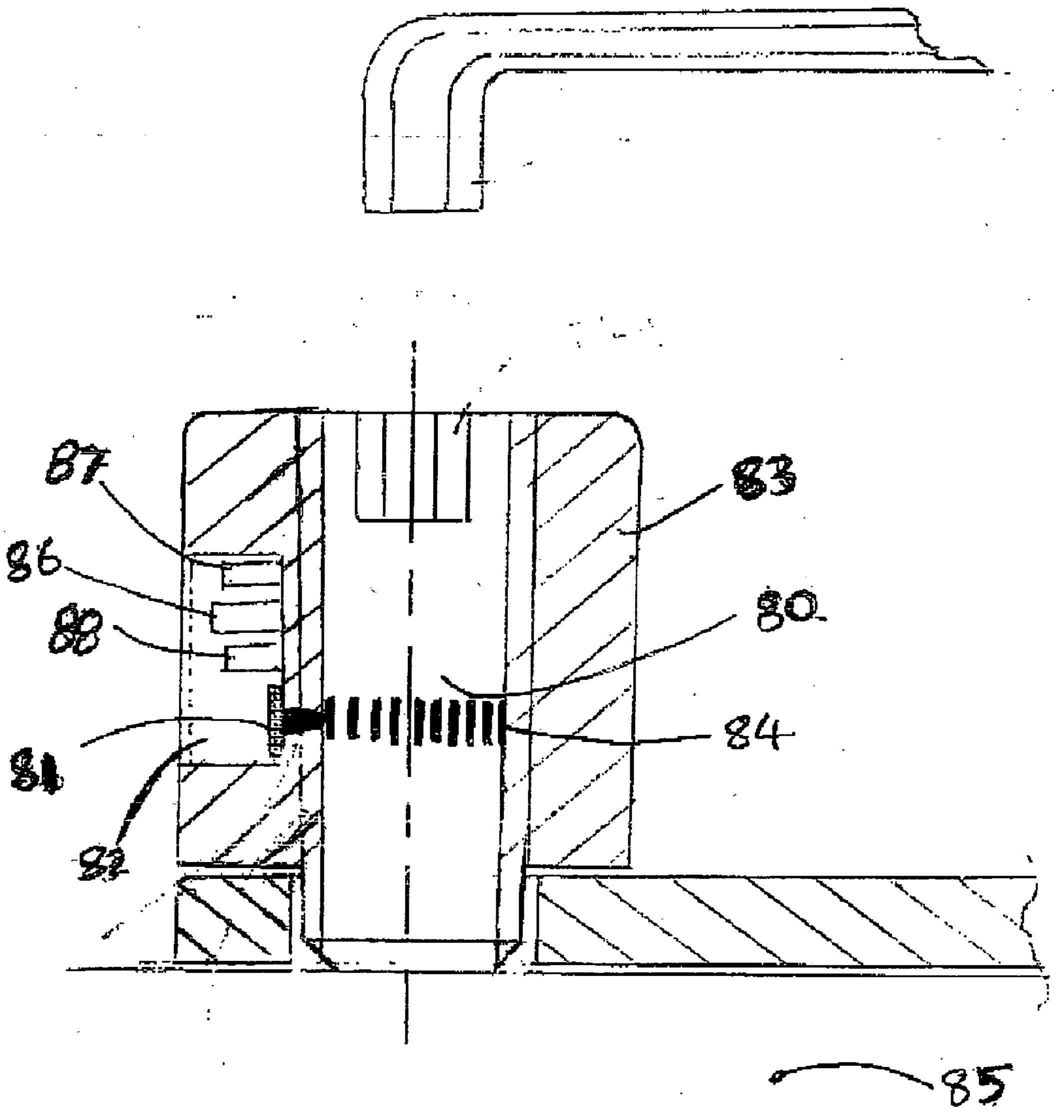


Figure 16 of 16

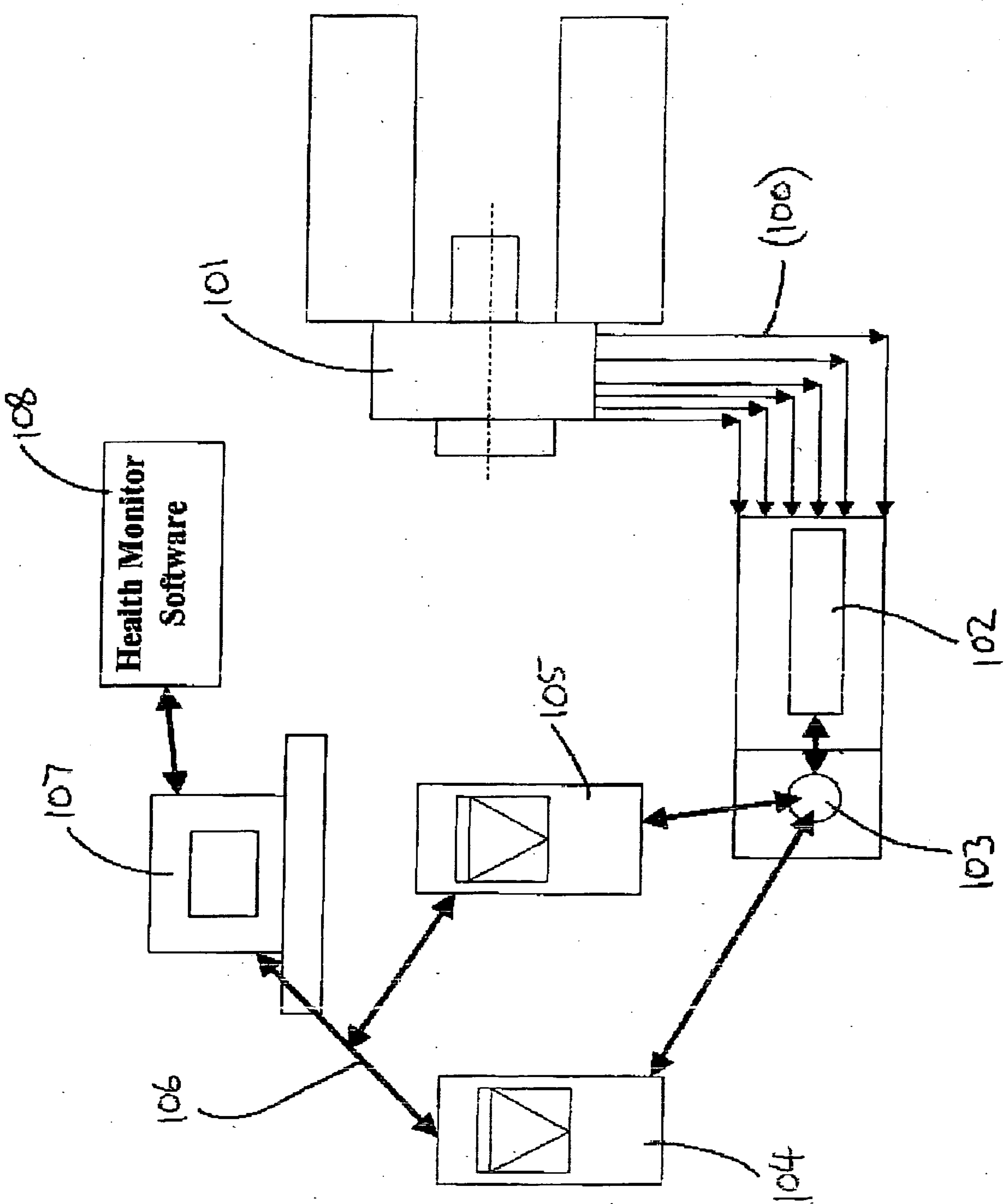


Figure 11 of 16

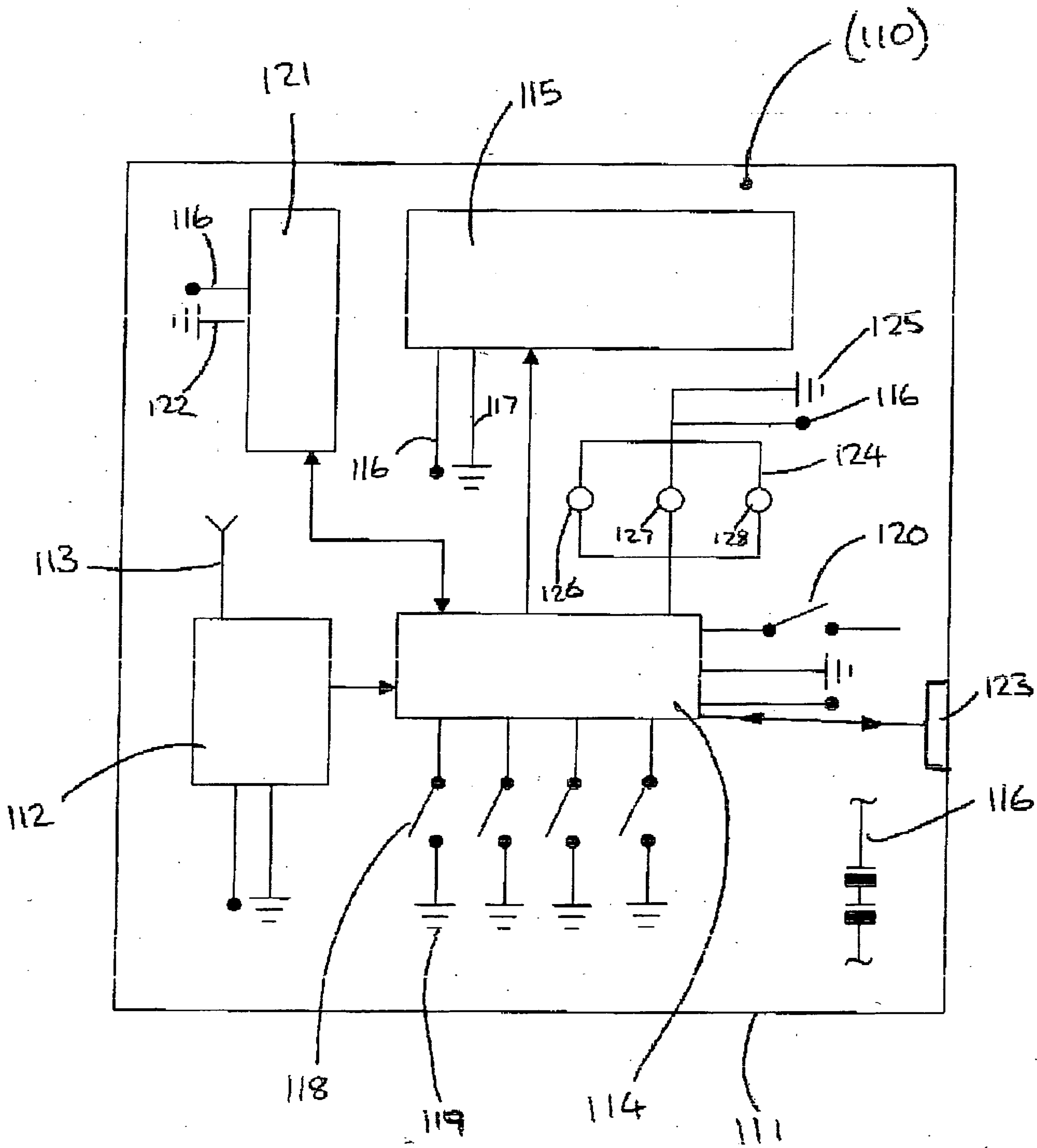
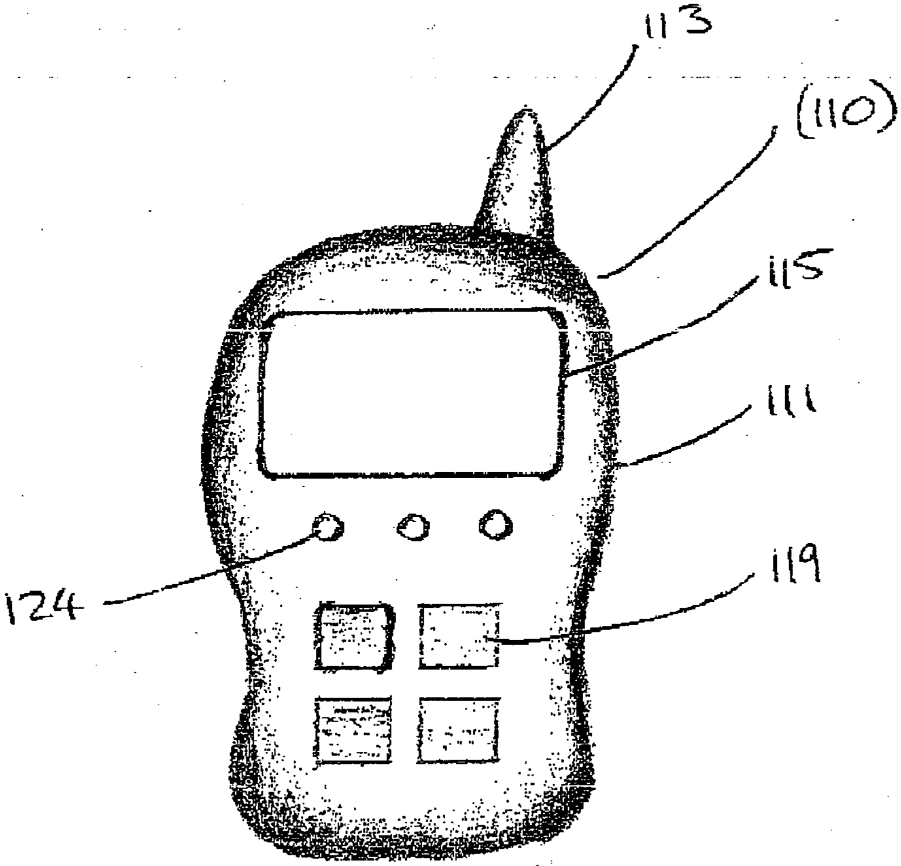
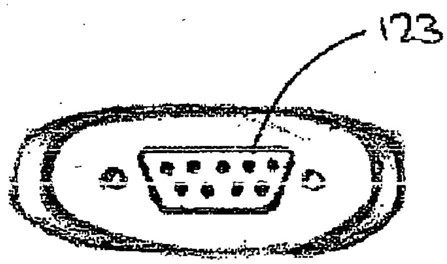


Figure 12 of 16





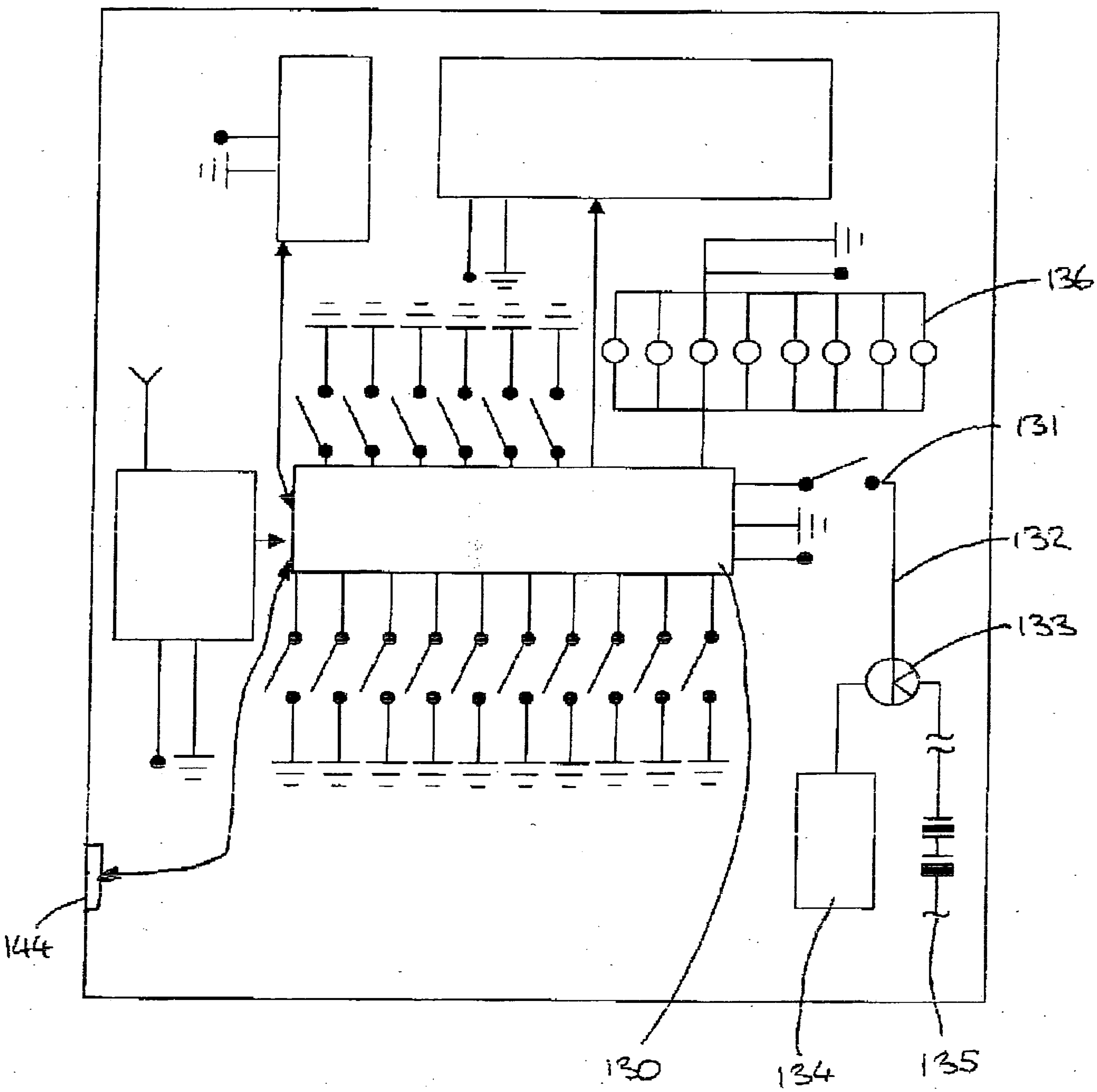

136
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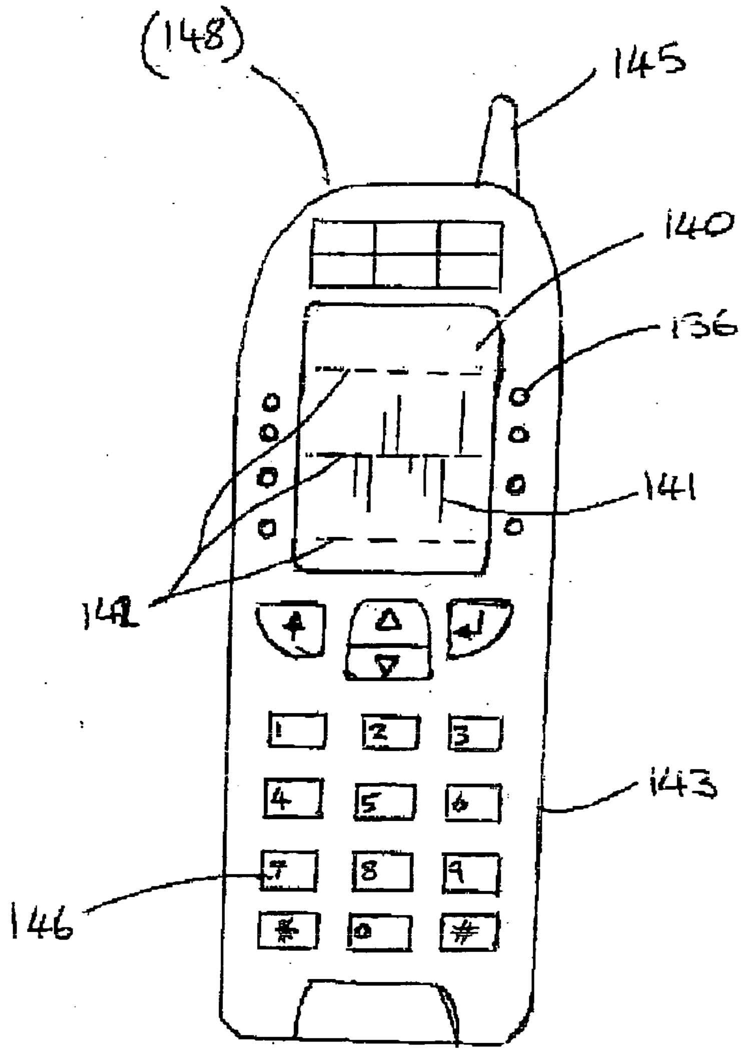
Figure 14 of 16



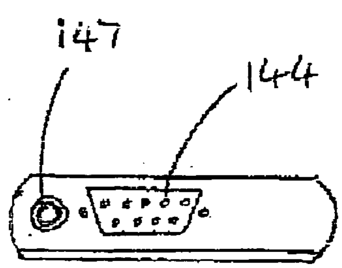


Figure 15 of 16

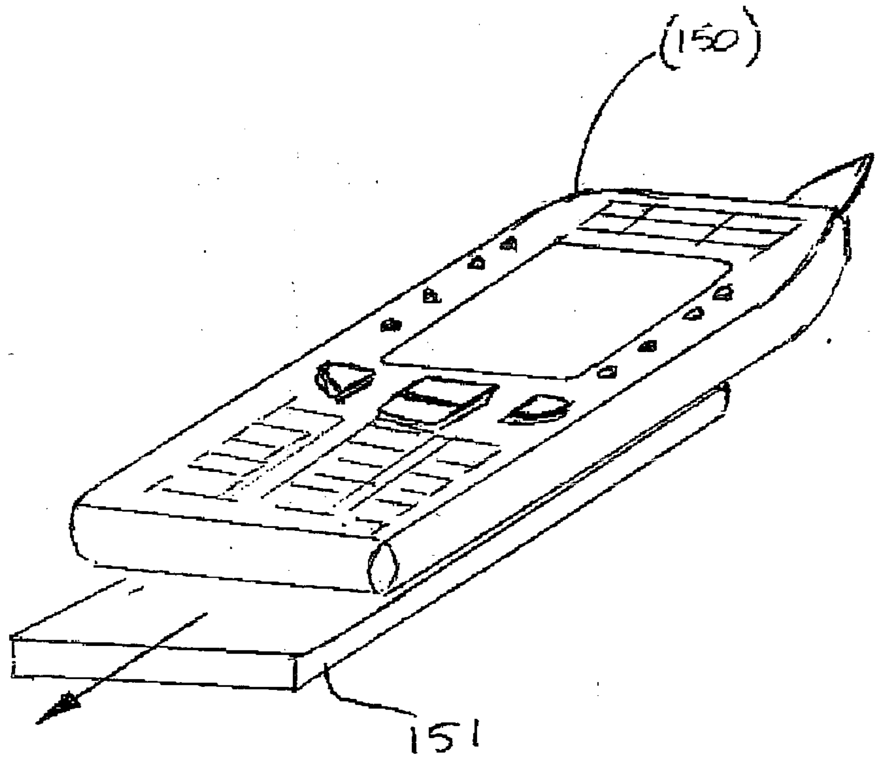


Figure 16 of 16